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# RESISTANCE TO *HETERODERA SCHACHTII* IN PATELLARES SECTION OF THE GENUS *BETA*[1]

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SUMMARY

Fifty-two accessions of the section Patellares wild beet (including 26 *Beta patellaris* MOQ., 13 *B. procumbens* CHR. SM. and 13 *B. webbiana* MOQ.) and 14 progeny families were selected and tested against sugarbeet cyst nematode, *Heterodera schachtii* SCHM. All Patellares species tested were highly resistant, but not immune, to the development of *H. schachtii*, after infection. This is the first report that mature female nematodes developed in the roots of *B. webbiana* plants. The occasional development of nematode cysts in roots of juvenile wild beets was, however, not a heritable genetic factor.

## INTRODUCTION

Investigations into the taxonomy of *Beta* have a long history. In 1927 the genus *Beta* was documentally divided into three sections, Patellares TR., Vulgares TR. and Corollinae TR. (TRANSCHEL, 1927). Since then various aspects of these beet species and subspecies have been actively pursued (ZOSSIMOVITCH, 1940; COONS, 1954, 1975). Among the 13 *Beta* species (belonging to four sections) investigated, only the three Patellares species, i.e., *B. patellaris* MOQ., *B. procumbens* CHR. SM. and *B. webbiana* MOQ., were resistant to the cyst nematode, *Heterodera schachtii* SCHM. (HIJNER, 1952; WINSLOW, 1954; GOLDEN, 1959). *Heterodera schachtii* is the most important nematode of sugarbeet, *B. vulgaris* L. (STEELE, 1984). It is possible to introgress *H. schachtii* resistance of Patellares sources into the sugarbeet genome through interspecific hybridization and subsequent back crosses (SAVITSKY, 1975; SPECKMANN & DE BOCK, 1982; HEIJBROEK et al., 1983; LOPTIEN, 1984).

Although individual species in the section Patellares have been classified as either immune or highly resistant to the sugarbeet nematode, levels of nematode resistance or susceptibility in these three species have not been defined on a broad base of germ-

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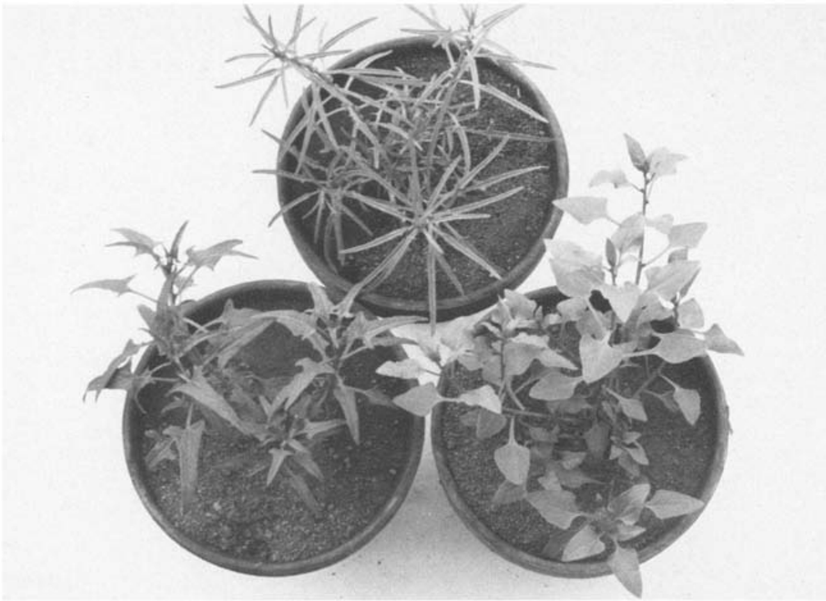

Fig. 1. Wild beet plants of the section Patellares, genus *Beta*. Top, *B. webbiana*; left, *B. procumbens*; right, *B. patellaris*.

plasms. During the past eight years I have been engaged in wild beet acquisition, evaluation, and utilization. This study was conducted to evaluate the levels of resistance to *H. schachtii* in some 50 Patellares accessions and the heritability of young beet cyst-bearing characteristics.

## MATERIALS AND METHODS

Seed from 52 accessions of the section Patellares wild beets collected from various sources were used in this study (Table 1). Included were 26 accessions of *B. patellaris* Moq., 13 of *B. procumbens* Chr. Sm., 13 of *B. webbiana* Moq., and 14 selections from their progeny (Fig. 1). Twenty-eight of the 52 accessions were derived from collections during the five trips to Europe, Asia Minor, North Africa, and Canary Islands made by the late Dr G. H. Coons in 1925, 1935, 1951, 1971, and 1975. The majority of Coons' materials was obtained from a collection that had been maintained at USDA-ARS, Beltsville, Maryland. The remainder of the germplasm was from Plant Introductions, materials previously maintained at Salinas station, and recent acquisitions and collections from other sources.

Seeds of wild beet species generally do not germinate readily without scarification. Sulfuric acid was used to scarify the seed coat, followed by neutralization with a 10% solution of baking soda (sodium bicarbonate; Arm and Hammer®). Some was accomplished by scratching the seed coat with sand paper. The treated seed was germinated in steam sterilized sand.

For testing the nematode resistance, seedlings of the Patellares species were transplanted at the two-leaf stage to aluminium foil cylinders (5.5 × 17.5 cm) containing 400 ml of *H. schachtii*-infested soil with 60 or more cysts per cylinder (YU & STEELE, 1981). Test plants were grown in a temperature controlled greenhouse at 21 to 27°C with a 16 hour photoperiod. Six to seven weeks after transplanting, roots of each plant were examined for white female cysts. All plants, regardless of the level of cyst development exhibited, were replanted in nematode-infested soil for two additional screenings. In the later tests, 20 brown cysts were pipetted into the soil immediately around the plant to ensure high nematode populations. At about 7 weeks after the third inoculation, plants which still supported fewer than 10 nematode cysts were classified as resistant. Four plants which had no cysts during testing and 10 plants which showed cysts on first and second, but not on subsequent testing, were selected and reproduced in greenhouse or in field plots. Progenies of these plants were again tested to evaluate the heritability of the cyst-supporting nature of the wild beets.

Table 1. Wild beet accessions used in this study[a].

| Species of *Beta* | Accession number | Origin of germplasm |
|---|---|---|
| *B. patellaris* | 1701 | USDA-ARS Salinas Station, stock seed. |
| | 1702 | H. Rietberg, The Netherlands. |
| | 1703 | USDA, SP673007-0, PI No. 198482, from San Felipe, Canary Island, 1951. |
| | 1705 | WBSI No. 88[b]. |
| | 1706 | WBSI No. 89[b]. |
| | 1708 | G. H. Coons' 9d, 1 plant, 1.6 km from Hotel Pampa, Las Palmas, Gran Canaria, Canary Islands, collected 7/17/71. |
| | 1709 | Coons' 11b, 1 large plant – many small, campanulate type seed, 47 km south of Las Palmas, Gran Canaria, collected 7/18/71. |
| | 1710 | Coons' 14a, 1 plant – campanulate type, Santa Cruz de Teneriffe, Canary Islands, collected 7/19/71. |
| | 1711 | Coons' 15a, shattered seed beneath plants, San Andres, Teneriffe, Canary Islands, collected 7/19/71. |
| | 1713 | G. E. Coe, probebly from Coons' 1951 collection, grown in greenhouse in 1967, harvested 6/15/67. |
| | 1714 | Coe, pool of Urcinate types, greenhouse, harvested 6/27/74. |
| | 1715 | PI No. 198480 and No. 198498, pool of Coons' 1951 and 1971 collections, harvested 8/30/73. |
| | 1716 | Coons', pool of 1951 and 1971 collections, increased in greenhouse, harvested 8/30/73, 10/10/73 and 12/20/73. |
| | 1717 | Coons, grown from pool of 1946 and subsequent lines, collected 2/15/75, 4/11/75 and 6/27/75. |
| | 1718 | Coons and daughters, composite type, Canary Islands, collected 8/7/75[c]. |
| | 1719 | Coons, shattered seed, Telde, Gran Canaria, collected 8/5/75[c]. |
| | 1720 | Coons, Gisa Chico, Teneriffe, collected 8/7/75[c]. |
| | 1721 | R. H. Helmerick, mix of *B. webbiana* and *B. patellaris*, Holly Sugar Corporation, Sheridan, Wyoming, 11/26/75; identified as *B. patellaris*. |
| | 1722 | Coons, shattered seeds, Telde, Gran Canaria, collected 8/5/75[c]. |
| | 1723 | Coons, San Andres, Teneriffe, collected 8/8/75[c]. |
| | 1724 | Coons, picked from 1 plant, Los Lilos, Teneriffe[c]. |
| | 1725 | Coons, shattered seeds, Mal Poloma, Gran Canaria[c]. |

Table 1. (Cont.)

| Species of *Beta* | Accession number | Origin of germplasm |
|---|---|---|
| *B. procumbens* | 1901 | H. Savitsky, greenhouse *B. procumbens*. |
| | 1902 | WBSI No. 107, 8918C2, 5918 O.P. *B. procubmens*[b]. |
| | 1903 | M. Planck, 1966, annual, seed from Japan Sugarbeet Improvement Foundation in 1968. |
| | 1904 | Coons, pool, S. B. Greenhouse, Beltsville, Maryland. |
| | 1909 | USDA, SP723000-0. |
| | 1913 | USDA, SP623002-0, *B. patellaris* × *B. procumbens*, amphidiploid, 2n = 54, produced at Beltsville. |
| | 1914 | USDA, SP533012-0, increase of PI No. 198493, collected at Baranca, Martianez, Canary Islands. |
| | 1915 | USDA, SP723000-1. |
| | 1916 | USDA, SP753007-0, increase of 1971 collection, from San Felipe, Teneriffe. |
| | 1917 | USDA, SP643000-0. |
| | 1918 | USDA, unknown origin, increase of 1950, Beltsville. |
| | 1919 | USDA, unknown origin. |
| *B. webbiana* | 1801 | USDA-ARS Salinas Station, stock seed. |
| | 1802 | WBSI No. 130, 8916, increase of 5916 in greehouse isolators, Salinas, 1968[b]. |
| | 1803 | USDA, SP623001-0. |
| | 1804 | USDA, SP723001-0. |
| | 1806 | Coons, S. B. greenhouse, Beltsville, collected 7/30/75. |
| | 1811 | Coons' 4b, 1 plant, shattered seed, very small, Isleta, Gran Canaria, collected 7/17/71. |
| | 1814 | Coons' 4e, several plants, Isleta, Gran Canaria, collected 7/17/71. |

[a] Eleven accessions that were not viable are not listed.
[b] Seed obtained from Dr J. S. McFarlane.
[c] Packages were originally listed as *B. procumbens*.

## RESULTS

Germination of the seeds from the 52 wild beet accessions (Table 1) was generally poor. It ranged from 0 to 35%. Eleven accessions (21%) failed to germinate. Nine were from Coons' collections.

Greenhouse tests showed that all three Patellares species were highly resistant, but not immune, to *H. schachtii*. The frequencies of cyst-free plants were 95.7%, 98.3%, and 93.1% for *B. patellaris, B. procumbens,* and *B. webbiana*, respectively (Table 2). Only small numbers of the young seedlings were found to have a few cysts clinging to their roots in the first test. These cysts were found on wild beets belonging to five *B. patellaris*, two *B. procumbens,* and three *B. webbiana* accessions. In the second test, a reduced number of cysts was detected in 5 of the 20 cyst-bearing plants from the first test. These five plants supported no cyst development in the third test. No cysts were observed on the remainder of the inoculated wild beets.

Table 2. Development of *Heterodera schachtii* cysts in Patellares species of the genus *Beta*.

| Source species | Number of plants | Number of accessions | Number of cysts/plant | | |
|---|---|---|---|---|---|
| | | | 1st test | 2nd test | 3rd test |
| *B. patellaris* | 224 (95.7%) | 22 | 0 | 0 | 0 |
| | 6 | 2 | 1–8 | 0 | 0 |
| | 1 | 1 | 2 | 4 | 0 |
| | 2 | 2 | > 10 | 0 | 0 |
| | 1 | 1 | > 10 | 3 | (dead) |
| *B. procumbens*[a] | 296 (98.3%) | 12 | 0 | 0 | 0 |
| | 3 | 1 | 1–5 | 0 | 0 |
| | 2 | 2 | > 10 | 3–7 | 0 |
| *B. webbiana* | 67 (93.1%) | 7 | 0 | 0 | 0 |
| | 3 | 2 | 1–9 | 0 | 0 |
| | 1 | 1 | > 10 | 0 | (dead) |
| | 1 | 1 | > 10 | 3 | 0 |

[a] From Yu (1982).

With the same test for resistance, there were no statistical differences (based on Chi-square tests) in the high levels of resistance between groups of progeny derived from cyst-bearing and cyst-free wild beet parents (Table 3). In both types of progenies, rates of resistance to *H. schachtii* equal to or higher than those exhibited by their parental populations were observed, i.e., 97.6% vs. 95.7% for the cyst-bearing *B. patellaris* plants, and 98.1% and 99.0% vs. 98.3% for cyst-bearing and cyst-free *B. procumbens*.

## DISCUSSION

Although his name was not listed, the majority of the accessions in the USDA collection (Table 1) probably was derived from Coons' earlier collections. The comparatively low germination rates of the wild beet collections suggested that a prolonged exposure of the seed to uncontrolled conditions may have caused significant losses in seed viability. The most critical factor for the safe storage of seeds is moisture content, especially for sealed storage (Bass, 1981). Undesirable storage environments, such as high humidity and high temperature, usually accelerate decline of viability of seed (Kreyger, 1954; Justice & Bass, 1978).

It is obvious that resistance factors in the Patellares species resulted in high mortality of *H. schachtii* juveniles feeding on the wild beets and their derivatives (Yu, 1984). Resistance in these genotypes was not due to the failure of nematode larvae to enter roots of resistant hosts, but was due to failure of the large majority of larvae to achieve full development (Yu & Steele, 1981). The mechanism for nematode resistance of this Patellares origin has been attributed to antibiosis, which was triggered by the presence of a phytoalexin that formed after infection (Yu, 1982; Yu & Jones, 1983).

Table 3. Development of *Heterodera schachtii* cysts in progeny of the selected cyst-bearing (+ cysts) and cyst-free (0 cyst) Patellares plants.

| Source species | Cyst type | Plant number | Number of progenies | Nematode development | |
|---|---|---|---|---|---|
| | | | | 0 cyst | + cysts |
| *B. patellaris* | + cysts | 17A1 | 11 | 11 | 0 |
| | | 17A2 | 22 | 21 | 1 |
| | | 17A3 | 17 | 16 | 1 |
| | | 17C1 | 21 | 21 | 0 |
| | | 17C4 | 11 | 11 | 0 |
| | | 17D1 | 11 | 10 | 1 |
| | | 17E1 | 31 | 31 | 0 |
| | | | 124 | 121 (97.6%) | 3 |
| *B. procumbens* | + cysts | 19A1 | 89 | 89 | 0 |
| | | 19A3 | 152 | 148 | 4 |
| | | 19A4 | 22 | 21 | 1 |
| | | | 263 | 258 (98.1%) | 5 |
| *B. procumbens* | 0 cyst | 1902-1 | 26 | 26 | 0 |
| | | 1909-1 | 28 | 28 | 0 |
| | | 1913-1 | 23 | 22 | 1 |
| | | 1915-1 | 24 | 24 | 0 |
| | | | 101 | 100 (99.0%) | 1 |

This resistance is, therefore, a postinfectional resistance (GIEBEL, 1982).

In this study nematode cysts have developed in all three Patellares species (Tables 2 and 3). For the first time the development of adult females of *H. schachtii* in *B. webbiana* species (Table 2) was observed. Occasional development of adult females was previously reported only in *B. procumbens* (YU, 1982; STEELE et al., 1983) and *B. patellaris* (SHEPHERD, 1959; STEELE & SAVITSKY, 1962). On the other hand, adult males of *H. schachtii* have been detected previously in all three Patellares species (GOLDEN, 1958; SHEPHERD, 1957). Nematode resistance in the Patellares species seems to have strengthened as plants became mature. No cysts were detected at the end of the third test (Table 2) on any of the test plants. Seedlings were approximately five months old at this stage. Plants of the section Patellares, therefore, may have the capability of establishing so-called adult plant resistance, or age resistance (HORBER, 1980).

The casual development of nematode cysts in young wild beets may or may not be a characteristic transmittible to their offspring. In both cyst-bearing and cyst-free progeny families, only a limited number of plants sustained cyst development (Table 3). The fact that cyst-bearing plants generated about equal or even higher numbers of cyst-free offspring as compared to their parental populations (Tables 2 and 3) indicated that occasional support of the cyst development was not under genetic control. Presumably, the influence of a specific environment may favor the plant or the parasite unequally, which affects the expression of susceptibility. In this case, such an effect was observed through the occasional development of adult females on the juvenile wild beets.


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